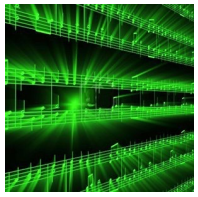
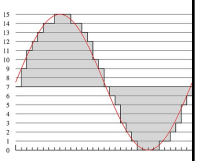
Penn Engineering

ESE





Lecture #19 – Operating Systems (OS)

ESE 1500 – Digital Audio Basics

ESE1509 Spring 2023

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Observation

- **We want our phones (and computers) to do many things at once.**
- **If we dedicate a processor to MP3 decoding**
  - It will sit idle most of the time
  - MP3 decoding (and many other things) do not consume a modern processor
- **Idea: Maybe we can share the processor among tasks?**

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Outline

- **Review**
- **Worksheet: Virtualization In Action**

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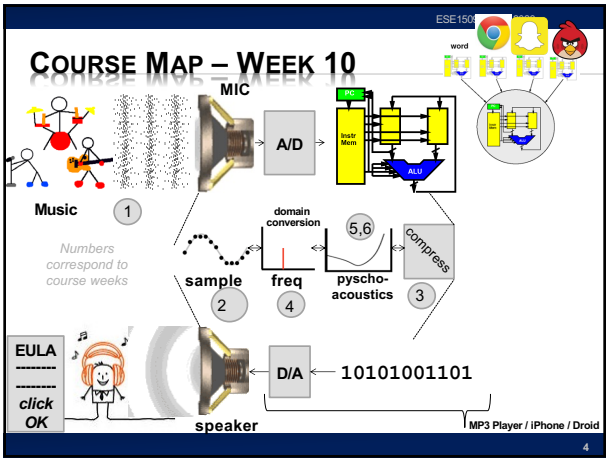
Course Map – Week 10



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Virtualization

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Idea

- **Virtualize the processor**
  - Make it look like we have multiple processors
  - With each program running on its own processor
- **"Own" processor**
  - Can put data in memory where it wants
  - Doesn't have to worry about another program scribbling over its memory
  - Its state is preserved and isolated
  - Looks like it runs all the time on the processor
    - Doesn't need to be programmed to allow other programs to run

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STRATEGY

- **Time-share single processor in time**
  - Store all process state in memory
    - Process = virtual processor
  - Iterate through processes
    - Restore process state
    - Run for a number of cycles
    - Save process state

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IDEA REFINED

- **Can capture state of a processor**
  - All the information that defines the current point in the computation
  - i.e. program counter, data and instruction memory
- **Can save that in memory**
  - A different memory from what the process sees
  - (could be different range of addresses)
- **Fully represents the running program**
- **Can restore that from memory to the processor**
- **Can save/restore without affecting the functional behavior of the program**

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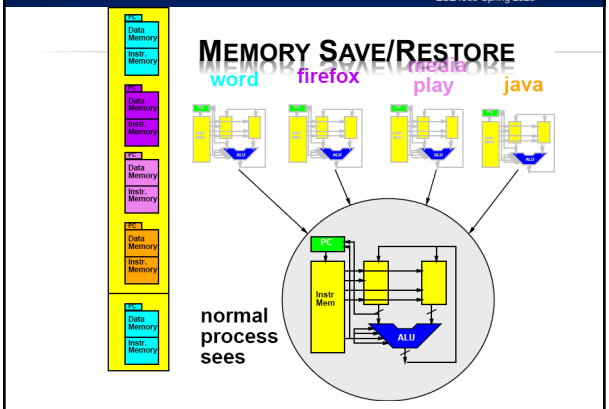
MEMORY SAVE/RESTORE



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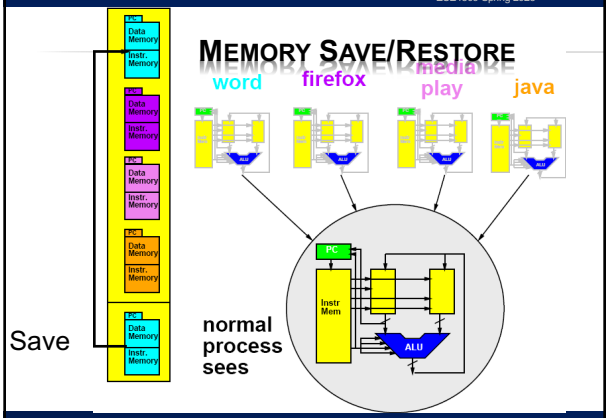
MEMORY SAVE/RESTORE



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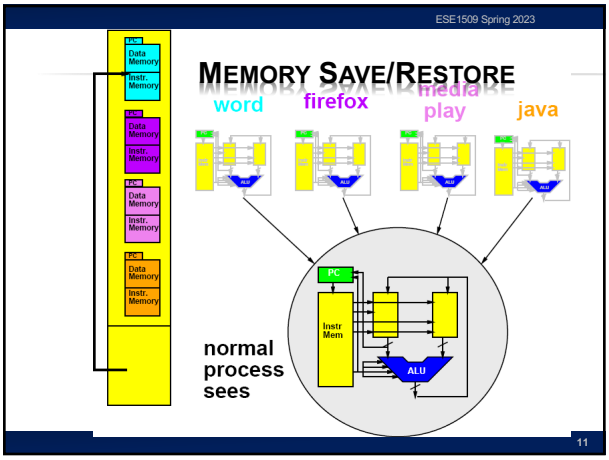
MEMORY SAVE/RESTORE



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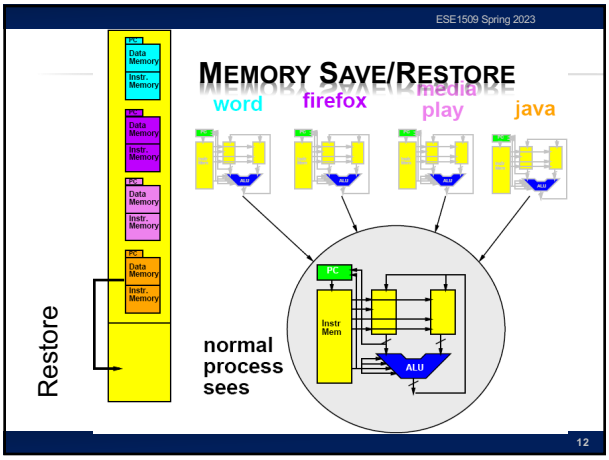
MEMORY SAVE/RESTORE



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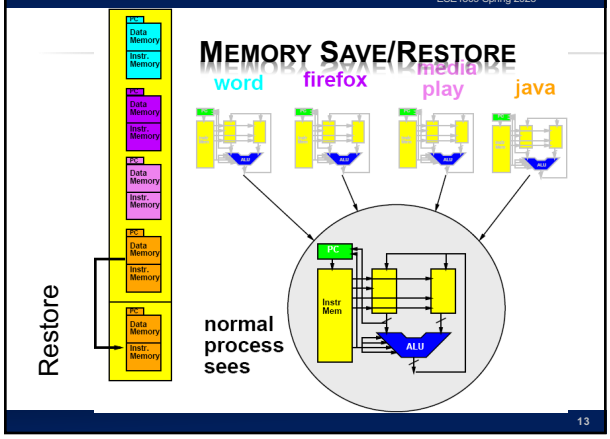
Memory Save/Restore



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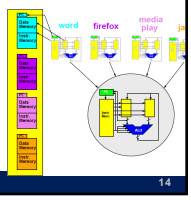
Sharing Processor

- **Now that we can save/restore the state**
- **Can share processor among processes**
  - (Restore state; run for time; save state)
- **Isolation: none of the processes need to know about each other**
  - Each thinks it has the whole machine
  - Just need to restore/save state around epochs where the process gets to run on the processor



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Worksheet Exercise

Demonstration

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Worksheet: Execution Exercise

- **We're going to simulate the computer and watch the processor state**

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Execution Exercise

- **Simulate A for 12 cycles**
  - Work together as class

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Simulate Swapping

- **Imagine we ran A for 6 cycles (and saved state)**
- **Swap and Run B for 6 cycles**
- **Swap and Run A for next 6 cycles**
  - What should we get?
- **Swap and Run B for next 6 cycles**
- **Swap and Run A for next 6 cycles (time permit)**

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SIMULATE SWAPPING

- Simulate B for 6 cycles
  - Individually
- What get for +6 line?

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SIMULATE SWAPPING

- Swap in A+6 and Simulate for 6 cycles (to 12)
  - individually
- What get for +12 line?
- Compare to what we got on A simulation?

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SIMULATE SWAPPING

- Swap in B+6 and Simulate for 6 cycles (to 12)
  - individually
- What get on +12 line?

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SIMULATE SWAPPING (TIME PERMITTING)

- Swap in A+6 and Simulate for 6 cycles (to 18)
  - individually
- What get on +18 line?

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SIMULATE SWAPPING

- Imagine we ran A for 6 cycles (and saved state)
- Swap and Run B for 6 cycles
- Swap and Run A for next 6 cycles
- Swap and Run B for next 6 cycles
- Swap and Run A for next 6 cycles (time permit)

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CONCLUDE

- Can Time Share Processor
- Key is saving/restoring state of computation
- Interleave computation of all the processes

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REVIEW: KEY IDEA

- **Can capture state of a processor**
  - All the information that defines the current point in the computation (PC, data and instruction mem)
- **Can save that in memory**
  - A different memory from what the process sees
  - (could be different range of addresses)
- **Fully represents the running program**
- **Can restore that from memory to the processor**
- **Can save/restore without affecting the functional behavior of the program**
- **Time-share processor → pretend have unlimited number**

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MEDIA PROCESSORS

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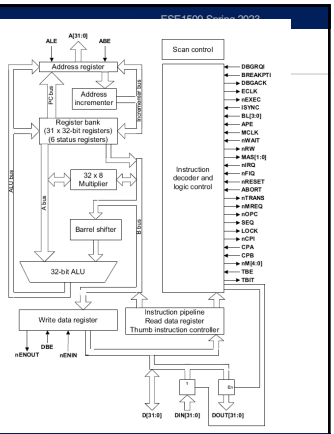
IPOD PROCESSOR

- **Early based on PortalPlayer series**
  - Two ARM7TDMI cores
  - 80MHz each



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APPLE A14 BIONIC

- **88mm², 5nm**
- **11.8 Billion Tr.**
- **iPhone 12**
- **6 ARM cores**
  - 2 fast (2.9--3GHz)
  - 4 low energy
- **4 custom GPUs**
- **16 Neural Engines**
  - 11 Trillion ops/s?

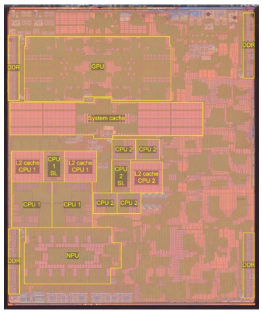

Image from https://www.extremetech.com/computing/318715-comparison-of-apple-m1-a14-shows-differences-in-
details: https://www.tomshardware.com/news/apple-a14-bionic-revealed
https://www.anandtech.com/show/16226/apple-silicon-m1-a14-deep-dive/2

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BIG IDEAS

- **Virtualize hardware**
  - Identify state; save/restore from memory
- **Program view: owns complete machine**
- **Allows programs to share limited physical hardware (e.g. processor)**
  - Provide illusion of unlimited hardware
- **Operating System is the program that manages this sharing**

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LEARN MORE

- **CIS3800 – Operating Systems**

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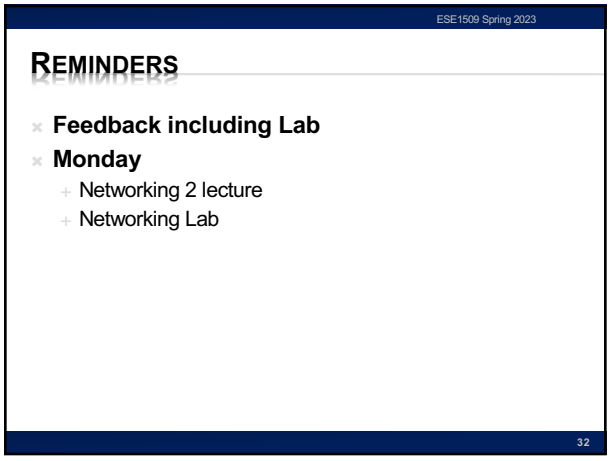
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REMINDERS
Feedback including Lab
Monday
Networking 2 lecture
Networking Lab
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